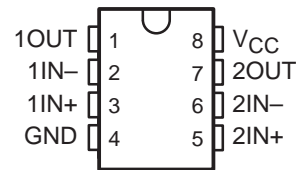


LM158, LM158A, LM258, LM258A LM358, LM358A, LM358Y, LM2904, LM2904Q DUAL OPERATIONAL AMPLIFIERS

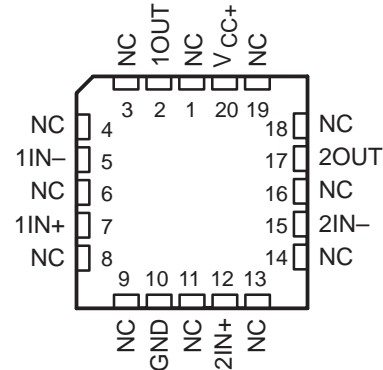
SLOS068C – JUNE 1976 – REVISED JULY 1998

- **Wide Range of Supply Voltages:**
 - Single Supply . . . 3 V to 30 V (LM2904 and LM2904Q . . . 3 V to 26 V) or
 - Dual Supplies
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Low Input Bias and Offset Parameters:**
 - Input Offset Voltage . . . 3 mV Typ
A Versions . . . 2 mV Typ
 - Input Offset Current . . . 2 nA Typ
 - Input Bias Current . . . 20 nA Typ
A Versions . . . 15 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . ± 32 V (LM2904 and LM2904Q . . . ± 26 V)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

D, JG, P, OR PW PACKAGE
(TOP VIEW)



LM158, LM158A . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

description

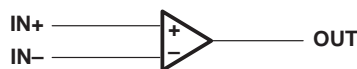
These devices consist of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 30 V (3 V to 26 V for the LM2904 and LM2904Q), and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily provides the required interface electronics without additional ± 5 -V supplies.

The LM2904Q is manufactured to demanding automotive requirements.

The LM158 and LM158A are characterized for operation over the full military temperature range of -55°C to 125°C . The LM258 and LM258A are characterized for operation from -25°C to 85°C , the LM358 and LM358A from 0°C to 70°C , and the LM2904 and LM2904Q from -40°C to 125°C .

logic diagram (each amplifier)



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1998, Texas Instruments Incorporated
On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

LM158, LM158A, LM258, LM258A LM358, LM358A, LM358Y, LM2904, LM2904Q DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

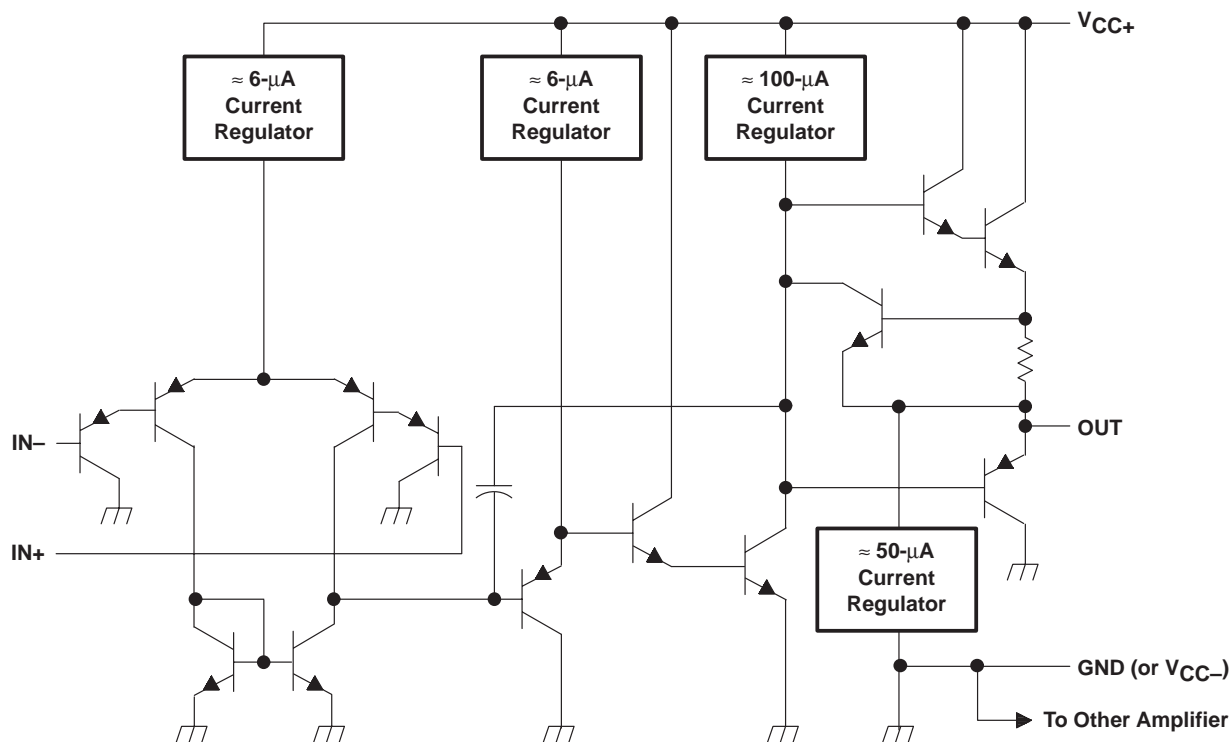
AVAILABLE OPTIONS

T _A	V _{IO(max)} AT 25°C	PACKAGED DEVICES					CHIP FORM (Y)
		SMALL OUTLINE (D)†	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)‡	
0°C to 70°C	7 mV	LM358D	—	—	LM358P	LM358PW	LM358Y
	3 mV	—	—	—	LM358AP	—	—
-25°C to 85°C	5 mV	LM258D	—	—	LM258P	—	—
	3 mV	—	—	—	LM258AP	—	—
-40°C to 125°C	7 mV	LM2904D	—	—	LM2904P	LM2904PW	—
		LM2904QD	—	—	LM2904QP	—	—
-55°C to 125°C	5 mV	LM158D	LM158FK	LM158JG	LM158P	—	—
	2 mV	—	LM158AFK	LM158AJG	—	—	—

† The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM358DR).

‡ The PW package is only available left-end taped and reeled.

schematic (each amplifier)



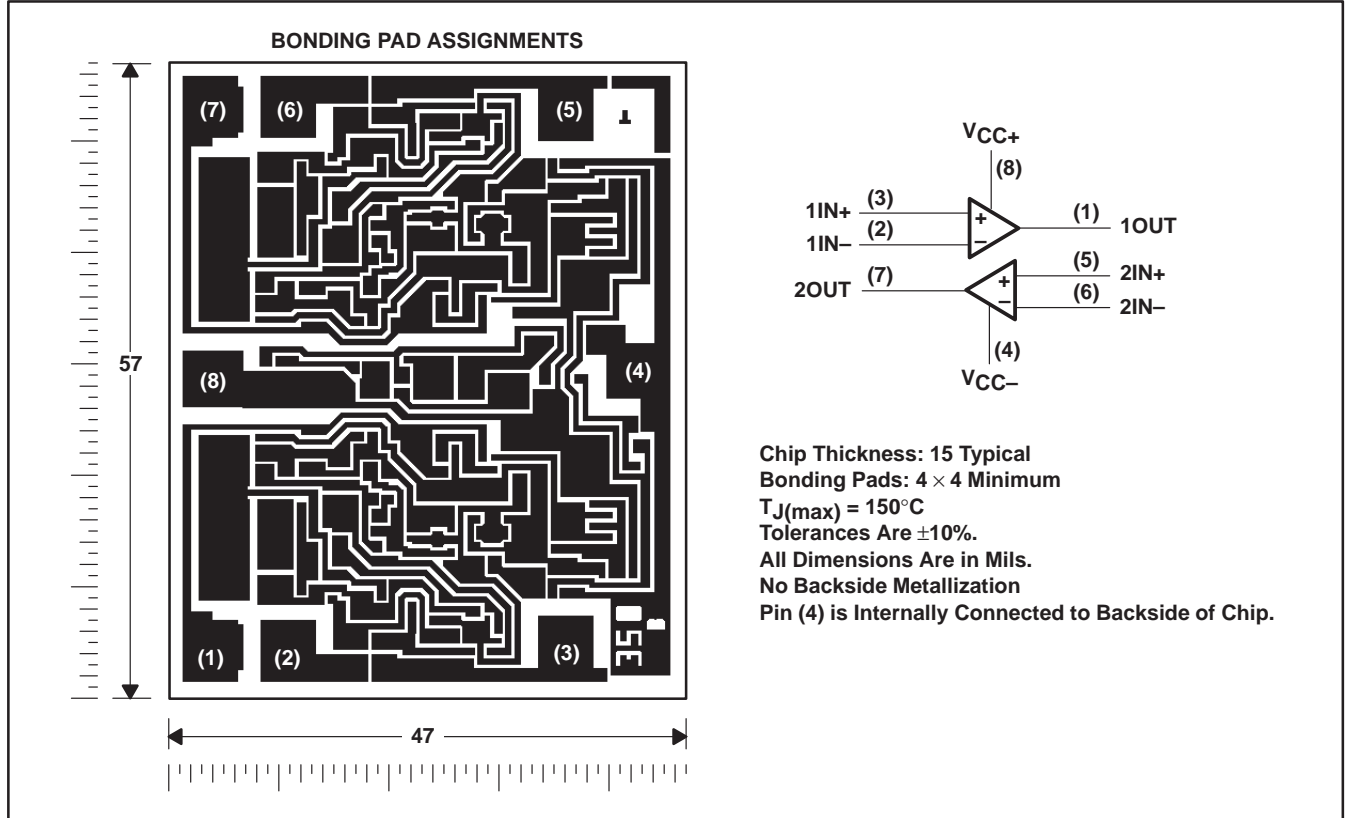
COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	7
Transistors	51
Capacitors	2

LM158, LM158A, LM258, LM258A
 LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

LM358Y chip information

These chips, when properly assembled, display characteristics similar to the LM358. Thermal compression or ultrasonic bonding can be used on the doped-aluminum bonding pads. Chips can be mounted with conductive epoxy or a gold-silicon preform.



**LM158, LM158A, LM258, LM258A
LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS**

SLOS068C – JUNE 1976 – REVISED JULY 1998

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

		LM158, LM158A LM258, LM258A LM358, LM358A	LM2904 LM2904Q	UNIT
Supply voltage, V_{CC} (see Note 1)		32	26	V
Differential input voltage, V_{ID} (see Note 2)		± 32	± 26	V
Input voltage, V_I (either input)		-0.3 to 32	-0.3 to 26	V
Duration of output short circuit (one amplifier) to ground at (or below) 25°C free-air temperature ($V_{CC} \leq 15$ V) (see Note 3)		Unlimited	Unlimited	
Continuous total power dissipation		See Dissipation Rating Table		
Operating free-air temperature range, T_A	LM158, LM158A	-55 to 125		°C
	LM258, LM258A	-25 to 85		
	LM358, LM358A	0 to 70		
	LM2904, LM2904Q		-40 to 125	
Storage temperature range, T_{stg}		-65 to 150	-65 to 150	°C
Case temperature for 60 seconds	FK package	260		°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, P, or PW package	260	260	°C

- NOTES: 1. All voltage values, except differential voltages and V_{CC} specified for measurement of I_{OS} , are with respect to the network ground terminal.
2. Differential voltages are at $IN+$ with respect to $IN-$.
3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW
PW	525 mW	4.2 mW/°C	336 mW	273 mW	–



LM158, LM158A, LM258, LM258A
LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	T_A ‡	LM158 LM258			LM358			UNIT	
			MIN	TYP§	MAX	MIN	TYP§	MAX		
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(\text{min})}$, $V_O = 1.4\text{ V}$	25°C	3	5		3	7	mV		
		Full range			7		9			
α_{VIO} Average temperature coefficient of input offset voltage		Full range	7			7			$\mu\text{V}/^\circ\text{C}$	
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C	2	30		2	50	nA		
		Full range			100		150			
α_{IIO} Average temperature coefficient of input offset current		Full range	10			10			$\text{pA}/^\circ\text{C}$	
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C	-20	-150		-20	-250	nA		
		Full range			-300		-500			
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	25°C	0 to $V_{CC}-1.5$		0 to $V_{CC}-1.5$			V		
		Full range	0 to $V_{CC}-2$		0 to $V_{CC}-2$					
V_{OH} High-level output voltage	$R_L \geq 2\text{ k}\Omega$	25°C	$V_{CC}-1.5$			$V_{CC}-1.5$			V	
		25°C								
		Full range	$R_L = 2\text{ k}\Omega$	26			26			
			$R_L \geq 10\text{ k}\Omega$	27 28			27 28			
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5 20			5 20			mV	
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L = \geq 2\text{ k}\Omega$	25°C	50	100		25	100	V/mV		
		Full range	25			15				
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(\text{min})}$	25°C	70	80		65	80	dB		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to MAX}$	25°C	65	100		65	100	dB		
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120			120			dB	
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	25°C	-20	-30		-20	-30	mA		
		Full range	-10			-10				
		Full range	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	10 20			10 20			
			$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	5			5			
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at -5 V, $V_O = 0$	25°C	$\pm 40 \pm 60$			$\pm 40 \pm 60$			mA	
I_{CC} Supply current (two amplifiers)	$V_O = 2.5\text{ V}$, No load	Full range	0.7 1.2			0.7 1.2			mA	
	$V_{CC} = \text{MAX}$, $V_O = 0.5\text{ V}$, No load	Full range	1 2			1 2				

† All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM 2904 and 30 V for others.

‡ Full range is -55°C to 125°C for LM158, -25°C to 85°C for LM258, 0°C to 70°C for LM358, and -40°C to 125°C for LM2904 and LM2904Q.

§ All typical values are at $T_A = 25^\circ\text{C}$.



**LM158, LM158A, LM258, LM258A
LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS**

SLOS068C – JUNE 1976 – REVISED JULY 1998

electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	T_A ‡	LM2904 LM2904Q			UNIT
			MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(min)}$, $V_O = 1.4\text{ V}$	25°C	3	7	mV	
		Full range	10			
α_{VIO} Average temperature coefficient of input offset voltage		Full range	7		$\mu\text{V}/^\circ\text{C}$	
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C	2	50	nA	
		Full range	300			
α_{IIO} Average temperature coefficient of input offset current		Full range	10		$\text{pA}/^\circ\text{C}$	
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C	-20	-250	nA	
		Full range	-500			
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	25°C	0 to $V_{CC}-1.5$		V	
		Full range	0 to $V_{CC}-2$			
V_{OH} High-level output voltage	$R_L \geq 2\text{ k}\Omega$	25°C			V	
	$R_L \geq 10\text{ k}\Omega$	25°C	$V_{CC}-1.5$			
	$V_{CC} = \text{MAX}$	$R_L = 2\text{ k}\Omega$	Full range	26		
		$R_L \geq 10\text{ k}\Omega$	Full range	23		24
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5	20	mV	
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$	25°C	25	100	V/mV	
		Full range	15			
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(min)}$	25°C	50	80	dB	
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to MAX}$	25°C	65	100	dB	
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120		dB	
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	25°C	-20	-30	mA	
		Full range	-10			
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	25°C	10	20		
		Full range	5			
$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	25°C	30		μA		
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at -5 V, $V_O = 0$	25°C	± 40	± 60	mA	
I_{CC} Supply current (two amplifiers)	$V_O = 2.5\text{ V}$, No load	Full range	0.7	1.2	mA	
	$V_{CC} = \text{MAX}$, $V_O = 0.5\text{ V}$, No load	Full range	1	2		

† All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM 2904 and 30 V for others.

‡ Full range is -55°C to 125°C for LM158, -25°C to 85°C for LM258, 0°C to 70°C for LM358, and -40°C to 125°C for LM2904 and LM2904Q.

§ All typical values are at $T_A = 25^\circ\text{C}$.



LM158, LM158A, LM258, LM258A
LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	T_A ‡	LM158A			LM258A			UNIT
			MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$, $V_{IC} = V_{ICR}(\text{min})$, $V_O = 1.4\text{ V}$	25°C			2		2	3	mV
		Full range			4			4	
α_{VIO} Average temperature coefficient of input offset voltage		Full range		7	15*		7	15	$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C			2		2	15	nA
		Full range						30	
α_{IIO} Average temperature coefficient of input offset current		Full range		10	200		10	200	$\text{pA}/^\circ\text{C}$
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C			-15		-15	-80	nA
		Full range						-100	
V_{ICR} Common-mode input voltage range	$V_{CC} = 30\text{ V}$	25°C		0 to $V_{CC}-1.5$		0 to $V_{CC}-1.5$			V
		Full range		0 to $V_{CC}-2$		0 to $V_{CC}-2$			
V_{OH} High-level output voltage	$R_L \geq 2\text{ k}\Omega$ $V_{CC} = 30\text{ V}$	25°C			$V_{CC}-1.5$		$V_{CC}-1.5$		V
		Full range	$R_L = 2\text{ k}\Omega$		26		26		
			$R_L \geq 10\text{ k}\Omega$		27	28		27	
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range		5	20		5	20	mV
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$	25°C		50	100		50	100	V/mV
		Full range		25			25		
CMRR Common-mode rejection ratio		25°C		70	80		70	80	dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		25°C		65	100		65	100	dB
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C			120			120	dB

*On products compliant to MIL-PRF-38535, this parameter is not production tested.

† All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified.

‡ Full range is -55°C to 125°C for LM158A, -25°C to 85°C for LM258A, and 0°C to 70°C for LM358A.

§ All typical values are at $T_A = 25^\circ\text{C}$.



LM158, LM158A, LM258, LM258A
 LM358, LM358A, LM358Y, LM2904, LM2904Q
 DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	T_A ‡	LM358A			UNIT
			MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V}$, $V_{IC} = V_{ICR(\text{min})}$, $V_O = 1.4\text{ V}$	25°C	2	3	mV	
		Full range	5			
α_{VIO} Average temperature coefficient of input offset voltage		Full range	7	20	$\mu\text{V}/^\circ\text{C}$	
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C	2	30	nA	
		Full range	75			
α_{IIO} Average temperature coefficient of input offset current		Full range	10	300	$\text{pA}/^\circ\text{C}$	
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C	-15	-100	nA	
		Full range	-200			
V_{ICR} Common-mode input voltage range	$V_{CC} = 30\text{ V}$	25°C	0 to $V_{CC}-1.5$		V	
		Full range	0 to $V_{CC}-2$			
V_{OH} High-level output voltage	$R_L \geq 2\text{ k}\Omega$ $V_{CC} = 30\text{ V}$	25°C	$V_{CC}-1.5$		V	
		Full range	$R_L = 2\text{ k}\Omega$	26		
			$R_L \geq 10\text{ k}\Omega$	27		28
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5	20	mV	
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$	25°C	25	100	V/mV	
		Full range	15			
CMRR Common-mode rejection ratio		25°C	65	80	dB	
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		25°C	65	100	dB	
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120		dB	

† All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified.

‡ Full range is -55°C to 125°C for LM158A, -25°C to 85°C for LM258A, and 0°C to 70°C for LM358A.

§ All typical values are at $T_A = 25^\circ\text{C}$.



LM158, LM158A, LM258, LM258A
LM358, LM358A, LM358Y, LM2904, LM2904Q
DUAL OPERATIONAL AMPLIFIERS

SLOS068C – JUNE 1976 – REVISED JULY 1998

electrical characteristics $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	LM358Y			UNIT		
		MIN	TYP	MAX			
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX, } V_{IC} = V_{ICR(\text{min})}, V_O = 1.4\text{ V}$	3	7		mV		
I_{IO} Input offset current		2	50		nA		
I_{IB} Input bias current		-20	-250		nA		
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	0 to $V_{CC}-1.5$			V		
V_{OH+} High-level output voltage	$R_L \geq 10\text{ k}\Omega$	$V_{CC}-1.5$			V		
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V, } V_O = 1\text{ V to } 11\text{ V, } R_L = \geq 2\text{ k}\Omega$	15	100		V/mV		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR(\text{min})}$	65	80		dB		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)		65	100		dB		
I_O Output current	$V_{CC} = 15\text{ V}$	$V_{ID} = 1\text{ V, } V_O = 0$		-20	-30	-60	mA
		$V_{ID} = -1\text{ V, } V_O = 15\text{ V}$		10	20		
	$V_{ID} = 1\text{ V, } V_O = 200\text{ mV}$		12	30			
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at -5 V, $V_O = 0$			± 40	± 60		mA
I_{CC} Supply current (four amplifiers)	$V_O = 2.5\text{ V, No load}$			0.7	1.2		mA
	$V_{CC} = \text{MAX, } V_O = 0.5\text{ V, No load}$			1	2		

† All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 30 V.

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.